

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 28

RADIO-FREQUENCY EXPERIMENTS



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Experiment Lesson 28

INTRODUCTION

The main functions of the r-f amplifier stage in a receiver are to increase the selectivity of the receiver, so that it may better discriminate against unwanted signals, and to increase its sensitivity so that weaker wanted signals may be received.

An experiment on regenerative detectors is also included in this lesson. Although the regenerative detector does amplify signals at the r-f frequency before detection, it is not actually an r-f amplifier. However, it is useful to experiment with these regenerative detectors at the same time that we perform r-f experiments.

EQUIPMENT NEEDED

Receiver chassis

Signal generator

Multimeter

Resistor Board

One 180-ohm resistor

One 4,700-ohm resistor

One 10 k-ohm 2-watt resistor

One 22 k-ohm 2-watt resistor

One 470 k-ohm resistor

One 500 k-ohm potentiometer

One 1.5-megohm resistor

Two 270- μf capacitors

One 470- μf capacitors

One 0.01- μf capacitor

One 0.05- μf capacitor

Magnet wire

Pickup coil (from previous experiments)

JOB 28-1

To wire a regenerative detector circuit.

Procedure

Step 1. Remove the 0.25- μf capacitor from the chassis, and the wire from pin 1 of 6BA6 to lug 3 of the volume control.

Step 2. Remove the 1 k-ohm resistor and ground the cathode of the 6BA6 tube.

Step 3. Remove the 22 k-ohm resistor between pin 6 and TS-J, and the 0.01 μf capacitor from this pin to chassis.

Step 4. Disconnect the 100 k-ohm resistor from pin 5 of the 6BA6 tube, and connect it across lugs 1 and 2 of TS-D, as shown in Fig. 28-1.

Step 5. Remove the wire from lug 3 of TS-C to pin 7 of the 6AT6 tube and connect in its place the 100 k-ohm resistor formerly across TS-C.

Step 6. Move the B+ lead at lug 1 of TS-C to lug 3 of TS-C.

Step 7. Connect a 100 k-ohm resistor (removed from resistor board) across lugs 1 and 3 of TS-C.

Step 8. Disconnect, at the triangle (Δ) terminal of the electrolytic capacitor, the wire from lug 2 of TS-D, and connect this wire to lug 1 of TS-C, so as to connect lug 1 of TS-C to lug 2 of TS-D.

Step 9. Connect a $0.25\text{-}\mu\text{f}$ capacitor from lug 1 of TS-C and the ground lug near pin 7 of the 6AT6 socket.

Step 10. Connect a $270\text{-}\mu\text{f}$ capacitor from lug 1 of TS-D to the ground lug near pin 6 on the 6BA6 socket.

Step 11. Remove the lead from pin 1 of the 6BA6 tube socket and return it to lug 1 of TS-J.

Step 12. Connect a $270\text{-}\mu\text{f}$ capacitor and 1.5-megohm resistor from pin 1 of the 6BA6 socket to lug 1 of TS-J.

Step 13. Cut two 6-inch lengths of wire, and strip the insulation from the ends. Connect one lead to the plate (pin 5) of the 6BA6 socket, and the other lead to lug 1 of TS-D. Bring the two leads to the top of the chassis through the large hole.

Step 14. Using magnet wire, wrap 5 turns

around the antenna coil as shown in Fig. 28-2. Be sure to wind them in the same direction shown in the figure—clockwise looking from the terminals. Make the turns snug, but not too tight to slide along the coil form.

Step 15. Connect the lead from the plate (pin 5) to the lead of the 5-turn coil nearest the mounting bracket, as shown in the figure. Connect the lead from TS-D to the other lead of the coil. Solder the connections, and cover them with tape.

Step 16. Mount the 500-k-ohm potentiometer in the proper hole on the chassis as shown in Fig. 28-1. This potentiometer will be used as a *regeneration control* to vary the screen voltage on the 6BA6 tube.

Step 17. Connect a lead between lug 2 of TS-J and terminal 1 of the regeneration potentiometer.

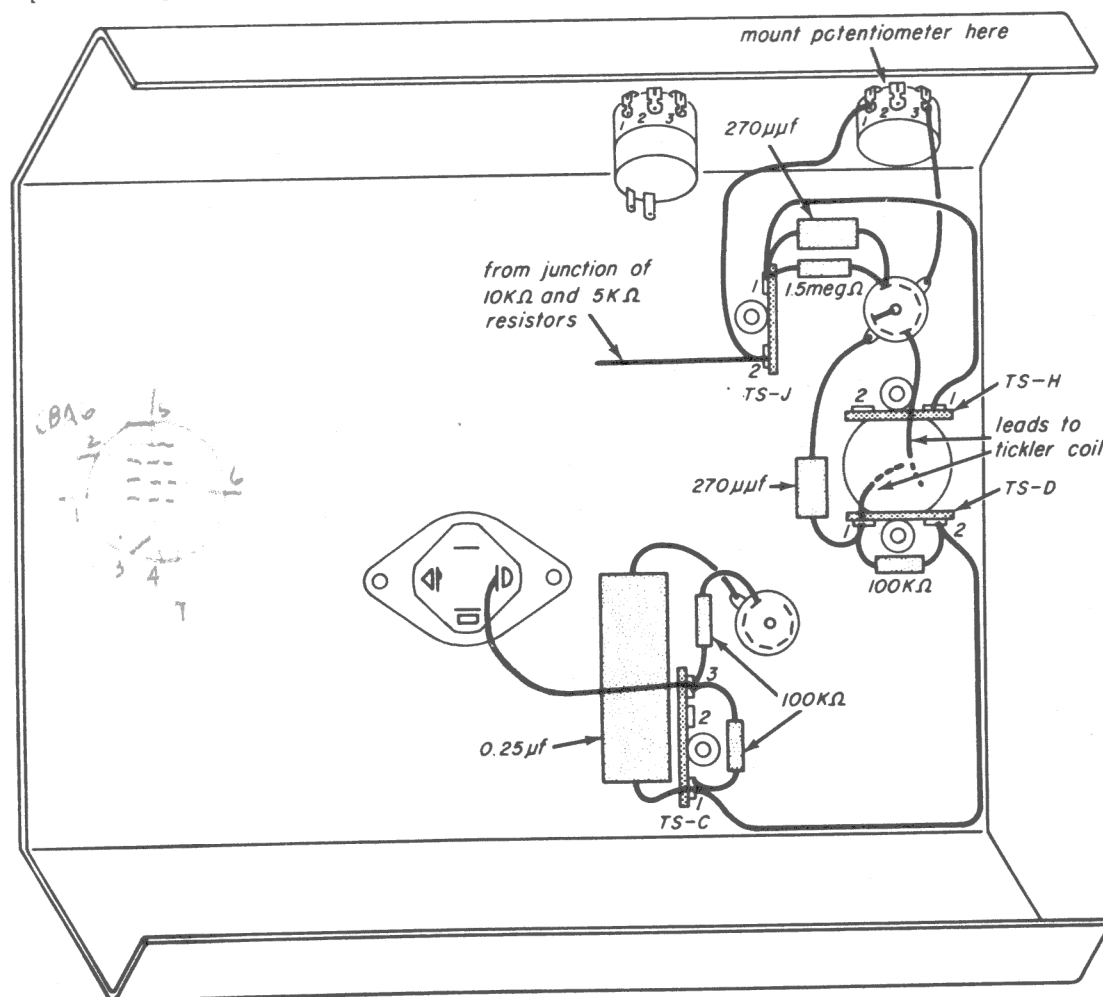


Fig. 28-1

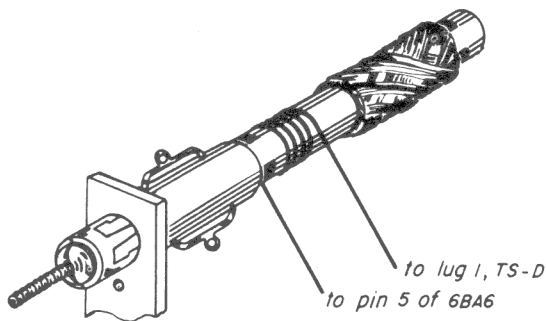


Fig. 28-2

Step 18. Connect terminal 3 of the potentiometer to the ground lug near pin 3 on the 6BA6 tube socket.

Step 19. Connect a lead between the center terminal of the potentiometer and pin 6 of the 6BA6 tube socket. (The wiring for this and the next 2 steps is shown in Fig. 28-3).

Step 20. Connect a $0.01\text{-}\mu\text{f}$ capacitor from pin 6 of the 6BA6 tube socket to the ground lug on TS-G.

Step 21. Connect the lead from terminal 3 of the volume control back to lug 2 of TS-H.

Step 22. Disconnect the $0.02\text{-}\mu\text{f}$ capacitor at pin 5 of the 6BA6 tube socket, and connect it to lug 1 of TS-D.

Step 23. Compare your chassis with the schematic diagram of Fig. 28-4 and the wiring diagram of Fig. 28-1 and Fig. 28-3 (your wiring should include all wiring shown on both diagrams, before you proceed).

EXPERIMENT 28-1

To study the characteristics of a regenerative detector.

Caution: The regenerative detector that you have built is capable of radiating r-f energy when it is in the oscillating state. Such radiation may cause interference to broadcast reception on nearby receivers.

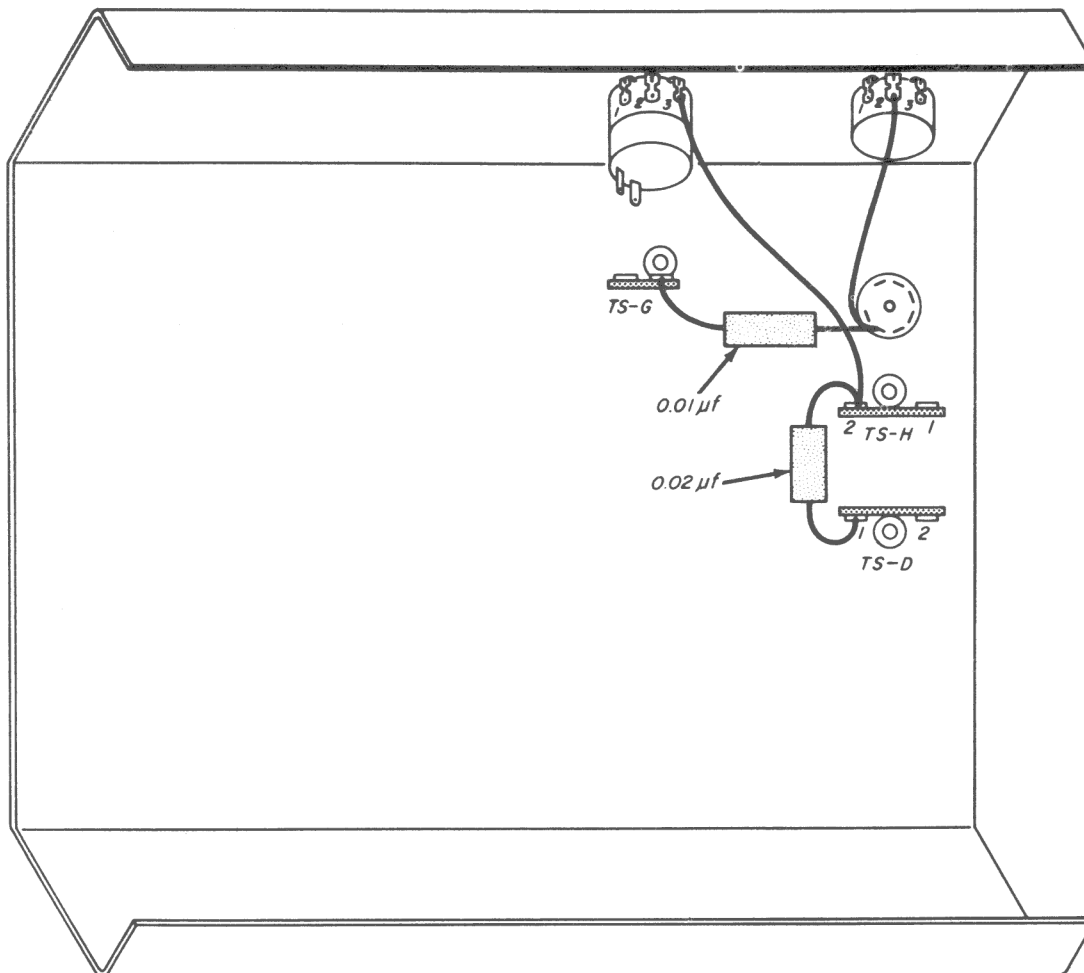


Fig. 28-3

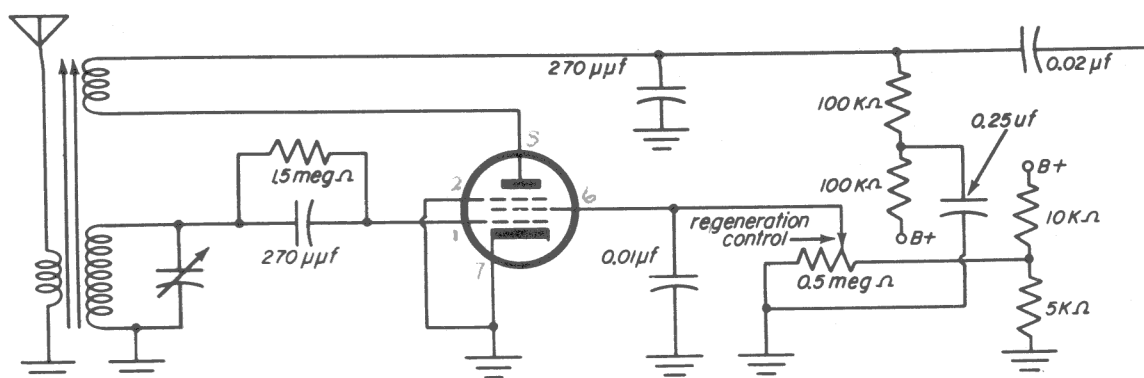


Fig. 28-4

The sensitivity of the receiver can be adjusted by the regeneration control. As the control is advanced clockwise, the sensitivity increases. The greatest sensitivity occurs just before the detector breaks into oscillation. The student should not operate the receiver in its oscillating state. Wilfully interfering with radio reception is a violation of the Rules and Regulations of the Federal Communications Commission and is punishable by fine of up to \$10,000, or imprisonment for 2 years, or both.

Procedure.

Step 1. Plug in the receiver and allow the tubes to warm up.

Step 2. Slip the pickup coil over the antenna coil. Connect one of the pickup coil leads to the ground terminal of the antenna coil, and connect the other lead to the antenna (10 feet or longer).

Step 3. Set up the meter to the 100 VDC scale, and measure the screen voltage. Adjust the regeneration control to give about 15 volts at the screen.

Step 4. Tune the receiver to pick up a broadcast station. Then advance the regeneration control counterclockwise to increase the screen voltage. The volume should increase, and then the receiver should begin to hiss, indicating the receiver is about to break into oscillation. Do not increase the screen voltage beyond this point.

If the receiver does not regenerate, move the small tickler coil closer to the antenna coil, or add one or two additional turns. If the receiver oscillates as soon as the screen voltage is turned up, move the tickler coil away from the antenna coil, or remove

one or two turns, or reverse the leads.

What happens to the volume just before the circuit breaks into oscillation? *decrease*

Why does it tend to oscillate?

How does the regeneration potentiometer control the amount of regeneration? *Thru control of screen voltage*

Step 5. Tune across the broadcast band, readjusting the regeneration control for each station to just before the point of oscillation. It should not be necessary to readjust the coupling between the coils once it has been correctly set unless there is a wide variation in the strengths of the signals received. See how many stations you can pick up.

How does the sensitivity of this detector compare with that of the detectors you have previously wired? *Better*

At what setting of the regeneration control does the detector have maximum sensitivity? *Just before oscillation*

Step 6. Remove the tape from the connections to the tickler coil, and reverse the connecting wires. Do this carefully to make sure that you really reverse the connections, and do not put them back the same way as before. Retape the connections.

Step 7. Operate the regenerative detector as described in Steps 4 and 5. Does it oscillate? Why? *degeneration*

volume oscillation
Discussion. The circuit of the regenerative detector has been shown in Fig. 28-4. As your experiments show, the regenerative detector is an extremely sensitive type of detector. Maximum sensitivity is obtained just before the circuit breaks into oscillation. The increased sensitivity and the oscillation are due to the r-f signal in the plate

circuit that is fed back in phase to the grid circuit. Since the screen voltage controls the gain of a pentode tube, varying the screen voltage controls the amount of r-f energy fed back through the tickler coil to the grid circuit. If the screen voltage is adjusted to give the maximum amount of feedback that is just not enough to sustain oscillation, maximum amplification and sensitivity of the detector will be obtained.

When the leads to the tickler coil are reversed, the feedback is not in phase, and reinforcement of the incoming signal cannot occur.

JOB 28-2

To wire the r-f amplifier circuit.

Procedure.

Step 1. Remove the following components and wiring:

- a. both 270- μf capacitors
- b. the 1.5-megohm resistor
- c. the lead between lug 1 of TS-H and lug 1 of TS-J
- d. all wiring associated with the regeneration control (3 leads)
- e. the 5 k-ohm 10-watt and the 10 k-ohm 5-watt resistors
- f. the wire from lug 2 of TS-F to lug 2 of TS-J
- g. the tickler coil and its two leads
- h. the 100 k-ohm resistor across TS-D
- i. the 100 k-ohm resistor across TS-C
- j. the 0.25- μf capacitor
- k. the lead between lug 1 of TS-C and lug 2 of TS-D
- l. the 0.02- μf capacitor between TS-D and TS-H
- m. the terminal strip on top of the chassis and all wiring to it.

Terminal strips D, H, and J should now have no connections, and there should be no connections to lugs 1 and 2 of TS-C. The 0.01- μf capacitor from pin 6 of the 6BA6 to TS-G remains connected.

Step 2. Remove ground lead and then insert a 180-ohm resistor between cathode and ground as in Fig. 28-5. This is a permanent connection, so cut your leads short, and dress the resistor as shown in the figure.

Step 3. Connect a 4,700-ohm resistor between pin 5 in the 6BA6 socket and lug 2 of TS-D.

Step 4. Connect a 22 k-ohm 2-watt resistor across lugs 1 and 2 of TS-D.

Step 5. Connect a 10 k-ohm 2-watt resistor across lugs 1 and 3 of TS-C.

Step 6. Connect a lead between lug 1 of TS-C and pin 6 of the 6BA6 socket.

Step 7. Connect a lead between lug 3 of TS-C and lug 1 of TS-D.

Step 8. Connect a 470- μf capacitor between pin 5 of the 6BA6 socket and lug 2 of TS-H.

Step 9. Connect a lead between lug 2 of TS-H and pin 6 (diode plate) of the 6AT6 tube.

Step 10. Connect a lead between lug 2 of TS-H and terminal 3 of the volume control.

Step 11. On top of the chassis, connect a lead between the antenna terminal of the antenna coil (not pick-up coil) and the stator terminal lug of the capacitor front section.

Step 12. Connect a 6-inch lead to this stator lug and pull it through the hole below the lug to the underside of the chassis. Connect the other end of this lead to pin 1 of the 6BA6.

Step 13. Connect a 0.02- μf capacitor from lug 1 of TS-E to a ground lug on the 6X5-GT socket.

Step 14. Disconnect the red lead of the output transformer from the square ($\square$) terminal of the electrolytic capacitor and connect it to the semi-circle ($\triangle$) terminal.

Compare your chassis with the wiring diagram of Fig. 28-5 and the schematic diagram of Fig. 28-6 before you proceed.

EXPERIMENT 28-2.

To measure the operating voltages of the r-f amplifier.

Procedure.

Step 1. Turn on the receiver and allow the tubes to warm up.

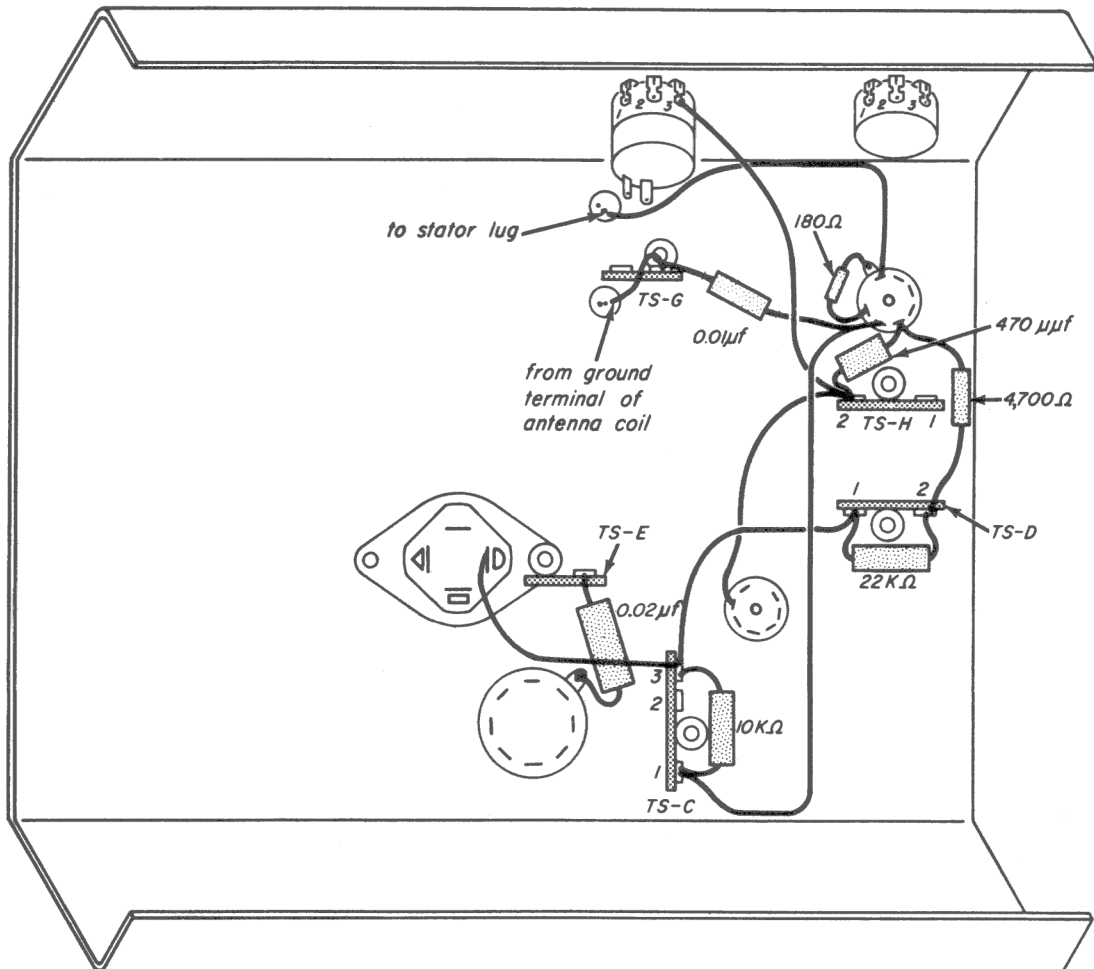


Fig. 28-5

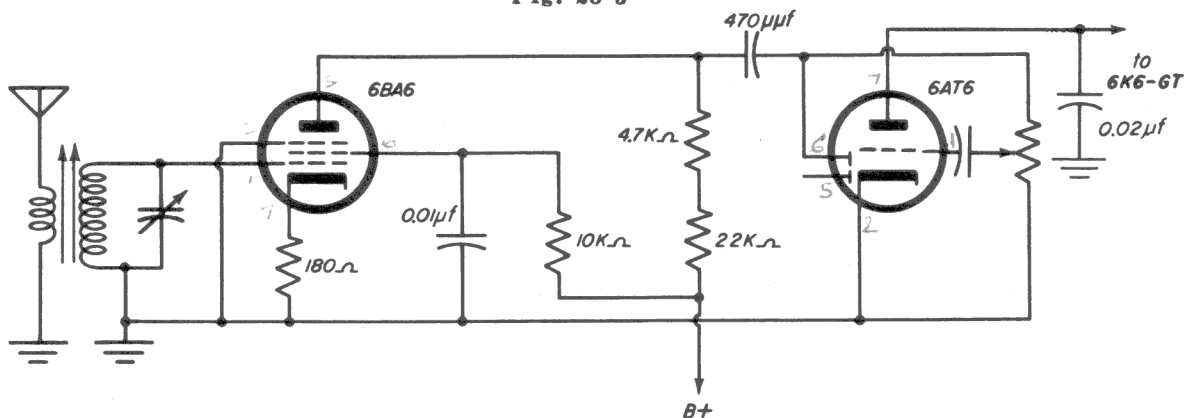


Fig. 28-6

Step 2. With the meter on the 500 VDC scale, measure the voltages at the plate and at the screen grid of the tube and enter them in Table A.

Step 3. With the meter set to the 5 VDC scale, measure the voltage at the cathode of the tube, and enter it in the table. Compare your voltages with those given in the table. If there is a discrepancy of much more than 20 percent, locate the trouble by checking your chassis against the wiring diagram of Fig. 28-5 and the schematic diagram of Fig. 28-6 before you proceed.

Step 4. Disconnect the receiver.

TABLE A - R-F AMPLIFIER		
Electrode	Measured Volts	Given Volts
Plate	14	20
Screen	130	160
Cathode	2.7	2.8

EXPERIMENT 28-3

To study the operation of a receiver consisting of an r-f amplifier and diode detector.

Procedure.

Step 1. With the 6BA6 tube in its socket, turn on the receiver, and allow the tubes to warm up.

Step 2. Connect the antenna to the free lead of the pickup coil.

Step 3. Tune the receiver through the broadcast range. If necessary, readjust the slug in the antenna coil to cover the band.

Turn the adjustment screw clockwise to cover the lower frequencies and counter-clockwise to cover the higher frequencies.

How does the performance of the combination r-f amplifier plus diode detector compare to the performance of the diode detector alone?

Note: In this experiment, you may notice that, near the end of the rotation of the volume control, the volume drops off rather than remaining at maximum. This does not indicate a defective volume control. The circuit acts in this way because of the temporary connection of the diode as a shunt detector.

Discussion. The addition of the r-f amplifier gives greater sensitivity than possessed by the diode detector alone. The selectivity is also slightly improved because the diode with its low impedance shunting is now not directly across the tuned circuit, but is isolated from the tuned circuit by the r-f amplifier.

However, the selectivity of the combination still is not very good. This is because many turns are required in the pickup coil, and these load the tuned circuit and reduce its selectivity. The loading of tuned circuits will be studied further in another experiment.

The diode detector used in this experiment, shown in Fig. 28-6, is connected across the load, rather than in series with it, as in the previous detectors studied. This type of detector is called a shunt detector. It is not used as a detector for radio receivers because it loads the previous circuit more than a series detector. It is used as a temporary detector for this experiment because the cathode of the diode is the

same as the cathode of the 6AT6 triode, and is already grounded.

EXPERIMENT 28-4

To study the selectivity of an r-f tuned circuit.

Procedure.

Step 1. Plug in the signal generator and allow it to warm up. Adjust the signal generator to band B, 600 kc, r-f output at maximum, modulation on.

Step 2. Disconnect the antenna and slip the 20-turn pickup coil over the antenna coil. Connect the signal-generator cable across the pickup-coil leads.

Step 3. Set up the multimeter to the 300 VAC scale, and insert the positive test lead in the output jack.

Step 4. Connect the red lead to the plate of the 6K6-GT output tube, and the black lead to ground.

Step 5. Turn on the receiver and allow the tubes to warm up.

Step 6. Tune the variable capacitor, and adjust the volume control to give about 100 volts output on the meter.

Step 7. With the signal generator set to exactly 600 kc, tune the variable capacitor carefully to exact resonance and reset the volume control, if necessary, to give exactly 100 volts output.

Step 8. Set the signal generator to 590 kc (estimate the setting carefully, and be as accurate as you can). Do not disturb the receiver capacitor setting. Read and record the voltage in the appropriate space in Table B.

Step 9. Continue as above until you have completely filled out Table B.

Step 10. Plot a graph of frequency versus voltage response on the graph paper provided at the end of this booklet. What does this graph tell you about the characteristics of the tuned circuit?

Discussion. The selectivity characteristic of a parallel-resonant tuned circuit is what enables the selection of the desired broadcast signal from the hundreds of signals that may be present at receiving location. The basic principles of this action have been covered in the Theory and Experiment Lessons on resonant circuits. A parallel-resonant circuit has a high impedance to the frequency to which it is resonant and little or no impedance to frequencies far removed from resonance. Thus,

TABLE B

Frequency	Voltage	
530	PICK UP COIL VOT GROUNDED 1	GROUNDED 5
540	2	3
550	3	6
560	4	7
570	10	12
580	14	17
590	20	48
600	100	100
610	27	40
620	17	20
630	12	11
640	8	12
650	5	7
660	4	7
670	3	6
680	2	5

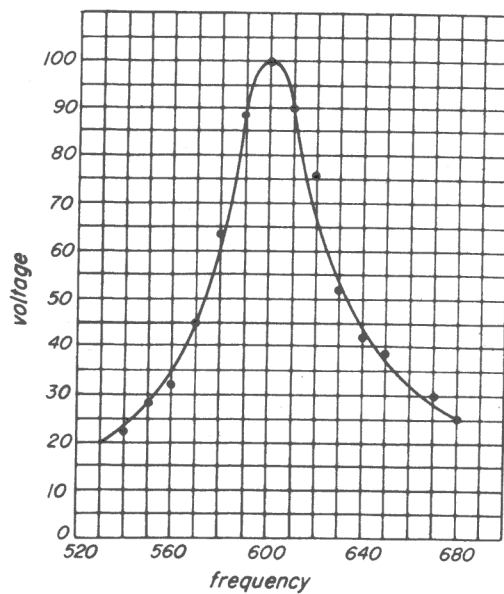


Fig. 28-7

a voltage will be developed across the tuned circuit, and applied to the grid of the amplifier tube, only for signals with a frequency at or close to the resonant frequency of the circuit.

The sharpness of the resonance curve is an indication of how well the tuned circuit will discriminate between the desired signal at the resonant frequency and an undesired signal whose frequency is close to the resonant frequency.

Typical results for this experiment are given in Table C and a graph plotted from these results is given in Fig. 28-7. You can see that the slope of the curve is symmetrical (has the same shape) on either side of the resonant point. This is unlike the curve obtained when the *capacity* is varied; check back on your results for the experiment on resonant circuits. When the capacity is varied, the response falls off faster on the low side of the resonant point. Thus, when a receiver is tuned, the tuning will be slightly more critical on the low-capacitor side of the resonant point than on the high side.

The curves obtained as a result of this experiment do not represent very sharply tuned circuits. This is also evident because the tuning of the receiver when listening to broadcast signals is not very sharp. The lack of sharpness is because the tuned circuit is loaded by the twenty-turn pickup coil. Further

TABLE C	
Frequency	Voltage
530	20
540	22
550	28
560	32
570	45
580	64
590	88
600	100
610	90
620	76
630	52
640	42
650	38
660	32
670	30
680	25

experiments to illustrate the effect of various types of loading on the sharpness of resonance will be performed in a later experiment lesson.

EXPERIMENT 28-5.

To study a method of measuring the inductance of a radio-frequency inductor.

Information. In Experiment Lesson 14, Inductance Experiments, you studied a method of measuring the inductance of an iron-core inductor designed for use at low frequencies. Generally, these methods are not used to measure the inductance of inductors used for radio-frequencies because

of the difficulty in accurately measuring voltages at radio frequencies. However, the inductance of such coils can be quite accurately measured using the technique outlined below.

The resonant frequency of a coil and capacitor combination is given by:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

A form more suited for calculation is:

$$f = \frac{159,000}{\sqrt{LC}}$$

where:

f = kilocycles

L = microhenries

C = micromicrofarads

If a coil of unknown inductance is connected across a known capacitor, and the resonant frequency of the combination is found, then the inductance can be calculated by:

$$L = \frac{1}{4\pi^2 f^2 C}$$

This is a transposition of the first formula above.

A more suitable form of this formula for calculation purposes is:

$$L = \frac{253 \times 10^8}{f^2 C}$$

where:

f = kilocycles

C = micromicrofarads

L = microhenries

In this experiment, the variable capacitor will be used as the known capacitor. The change in capacitance from maximum to minimum (ΔC , which is read as "delta C") is known from the manufacturer's specification to be 355 $\mu\mu\text{f}$. The minimum value of ca-

pacitance that results when the variable capacitor is placed in its minimum setting is not zero, but depends upon the wiring capacity, the distributed capacity of the coil, the input capacitance of any tubes connected across the tuned circuit, the trimmer capacitor, and the construction of the variable capacitor itself. The sum total of all of these, if the wiring has been done as instructed, will be about 60 $\mu\mu\text{f}$, of which about 30 $\mu\mu\text{f}$ is due to tube and wiring capacities. Thus, the remaining 30 $\mu\mu\text{f}$ is due to the trimmer capacitor, which is set to maximum capacity, and the minimum capacity of the variable capacitor itself, which is about 12 $\mu\mu\text{f}$. Thus, if this figure is used, the total capacitance in the circuit when the capacitor is set to minimum is 60 $\mu\mu\text{f}$, and when the capacitor is set to full mesh is 415 $\mu\mu\text{f}$. Either of these two values may be used to find the inductance of a coil. The value of 60 $\mu\mu\text{f}$ as the minimum total capacity is accurate enough for most purposes and it is recommended that the student use this value. If the student wishes, he may measure the actual minimum capacity of his own receiver, by using the technique described in the Appendix.

Procedure.

Step 1. Check to see that the signal generator has warmed up. Set the signal generator for Band C, maximum r-f output, modulation on.

Step 2. Set up the meter to the 15 VAC range, and insert the positive lead in the output jack.

Step 3. Turn on the receiver and allow the tubes to warm up.

Step 4. Wrap *one* turn of magnet wire around the antenna coil, and connect the signal-generator cable across the ends of this coil.

Step 5. Turn the core of the antenna coil to its minimum-inductance position (threaded screw maximum counterclockwise).

Step 6. Set the capacitor to its minimum capacity position.

Step 7. Set the trimmer to its maximum capacity position by turning the trimmer screw gently until it is tight—don't force it!

Step 8. Set the volume control about halfway and turn the signal generator through its range until the 400-cycle audio tone is heard. Tune it carefully for maximum response on the meter. Reduce the volume control setting if necessary to prevent overloading the meter. When making the final resonant-frequency adjustment with the signal generator, move the single-turn coil away from the antenna coil as far as possible. The one-turn coil should be only close enough to give a usable deflection on the meter. Read the resonant frequency as accurately as you can from the scale, and record it here:

4.45 Mc.
4450 kc

Step 9. Calculate the inductance of the coil at its minimum setting, using the proper formula given above and the appropriate value of capacity given in the discussion.

Step 10. Set the variable capacitor to its maximum capacity setting, and locate the new resonant frequency. It may be necessary to change bands to find the new resonant frequency. Record the new resonant frequency here:

1470 kc

Step 11. Calculate the inductance of the coil, using the new resonant frequency and the corresponding maximum capacity value:

28 μ h

How do the two values compare? They should agree quite closely.

Step 12. Readjust the core of the antenna coil to the maximum-inductance position (extending about $\frac{1}{4}$ inch out of the coil form).

Step 13. Set the variable capacitor to its minimum-capacity position, and find the resonant frequency of this new combination. Follow the procedure in Step 8. Record the resonant frequency here:

1400 kc

Step 14. Calculate the inductance of the coil in its maximum position. Record the result here:

15 μ h

Step 15. Readjust the capacitor to its maximum capacity position, and find the resonant frequency at this setting of the capacitor. Follow the procedure in Step 8. Record the resonant frequency here:

500 kc

Step 16. Calculate the maximum inductance of the coil. Record the result here:

24 μ h

How does this compare to the result obtained in Step 14? The two answers should be fairly close.

Step 17. Set the capacitor to its mid-position (turned one-quarter turn from full mesh position).

Step 18. Find the resonant frequency at this setting of the capacitor. Follow the procedure in Step 8. Record the resonant

frequency here:

825
kc

Step 19. Find the average of the two inductance values found in Steps 14 and 16. (Add the two values and divide by two.) Using this average value, find the value of capacitance at the midposition of the variable capacitor. Record the result here:

168
 μmf

Discussion. The directions given in this experiment are capable of giving results of considerable precision if they are carefully followed. If the value of the capacitor is accurately known, and the signal generator is accurately calibrated, very accurate measurements can be made. Results accurate to within $\pm 5\%$ should be obtained.

Typical results are as follows. At the minimum inductance setting of the antenna coil, $f_{C \min}$ is 3.72 mc, and $f_{C \max}$ is 1,400 kc, giving an average inductance $L_{\min}$ of about 30 microhenries. At the maximum inductance setting of the antenna coil, $f_{C \min}$ is 1,200 kc, and $f_{C \max}$ is 460 kc, giving an average inductance for $L_{\max}$ of about 290 microhenries.

At the midpoint of the variable capacitor setting, the total capacity is about 150 μmf . Since the distributed capacity total is about 60 μmf , the change in capacity of the variable capacitor from its minimum setting to its midpoint setting is about 90 μmf .

EXPERIMENT 28-6.

To study the variation of gain of an r-f stage with changes in frequency and with changes in the plate load.

Procedure.

Step 1. Disconnect at the grid (pin 1) of the 6BA6 tube, the wire from the stator

lug of the capacitor and temporarily solder this lead to the ground on lug 1 of TS-G.

Step 2. Connect a 470 k-ohm resistor from grid to ground of the 6BA6 tube socket.

Step 3. Check to see that the signal generator is on, set to band B, with sufficient r-f output, and modulation on. Set the signal generator to exactly 600 kc.

Step 4. Connect the high side of the signal generator cable to the plate (pin 5) of the 6BA6, and the ground terminal of the cable to the chassis.

Step 5. Check to see that the meter is set up to the 15 VAC scale with the positive test lead in the OUTPUT jack, and connect it to the plate of the output tube. Turn the receiver on and allow the tubes to warm up.

Step 6. Adjust the volume control to obtain a reading of exactly 1 volt on the meter.

Step 7. Move the high side of the cable to the grid (pin 1) of the 6BA6 tube. Note the reading on the meter. Divide the second reading by the first to obtain the gain of the stage. (Since the first reading is 1 volt, the gain of the stage is the second voltage reading.) Enter the result in the table below.

Step 8. Repeat Steps 5, 6 and 7 for frequencies of 1,000 kc and 1,600 kc, and enter your results in the appropriate place in the table.

TABLE D - 27 K-Ohm Plate Load	
Frequency	Gain
600 kc	4.6
1,000 kc	3.5
1,600 kc	2.5

Turn the receiver off when you have finished.

Step 9. Plot the results of gain at the three frequencies on the graph paper provided at the end of this lesson. Label this

curve 27 k-ohm since this is approximately the plate load at this point. Is the gain uniform over the broadcast band?

Step 10. Connect an 0.05- μ f capacitor across lugs 1 and 2 of TS-D. This shorts out the 22 k-ohm resistor for the radio-frequency signal but leaves the operating voltages on the tube unchanged. In this way, the effect of a change in plate load can be seen without introducing any other changes.

Step 11. Repeat steps 3 to 8 above, and enter your results in the table below:

TABLE E - 4.7 K-Ohm Plate Load	
Frequency	Gain
600 kc	3.6
1,000 kc	2.7
1,600 kc	2

Step 12. Measure the plate and screen voltages, and record them here:

Plate volts	83 volts d.c.	Screen volts	147 volts d.c.
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Step 13. Plot the results of gain versus frequency for the 4.7 k-ohm plate load on the same graph used for the previous curve so that a direct comparison can be made. Mark this curve with the value of the plate load and the plate voltage. Is there more or less gain at the lower plate load? Is the gain more or less uniform over the broadcast band?

Step 14. Remove the 0.05- μ f capacitor across TS-D and connect a short piece of wire across TS-D so as to short out the 22 k-ohm resistor.

Step 15. Repeat Steps 3 to 8 above, and

enter your results in the table below:

TABLE F

4.7 K-Ohm Plate Load	
Frequency	Gain
600 kc	14
1,000 kc	12.4
1,600 kc	10.9

Step 16. Measure the plate and screen voltages and record them here:

Plate volts	170 volts d.c.	Screen volts	170 volts d.c.
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Turn off the receiver when you are finished.

To what do you attribute the difference in gain at the same value of dynamic plate load?

Step 17. Plot the results on the same graph used for the previous curves. Mark this curve with the value of the plate load and the new plate voltage. How does the general shape of the two 4.7 k-ohm curves compare?

Discussion. Your results should show that, as in all amplifiers, the voltage gain depends upon the value of the plate load, and is higher with higher plate loads. At any value of plate load, the shunting effect of distributed and tube capacities causes the response to fall off as the frequency is increased, because the shunting capacities have decreased reactance. However, when the plate load is high, the shunting capacitance has greater effect at higher frequencies. This results in a faster falling off in response at the higher frequencies.

For example, even if the distributed capacitance across the plate load is as low as 5 μ f, its reactance at 500 kc is

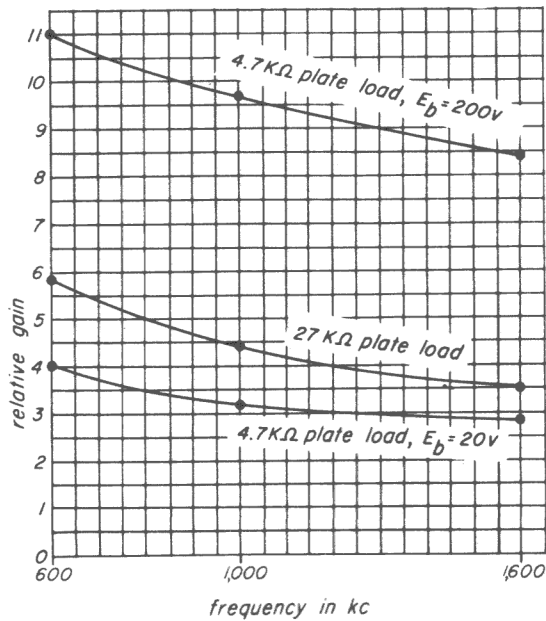


Fig. 28-8

about 60,000 ohms, and its reactance at 1,500 kc is about 20,000 ohms. When a 27 k-ohm plate load is used, the total plate-load impedance of the capacitor and resistance in parallel is about 20 k-ohms at 500 kc, and about 12 k-ohms at 1,500 kc. The effect of the shunting capacitance is to reduce the plate load by 40 percent as the frequency of the applied signal goes from 500 kc to 1,500 kc.

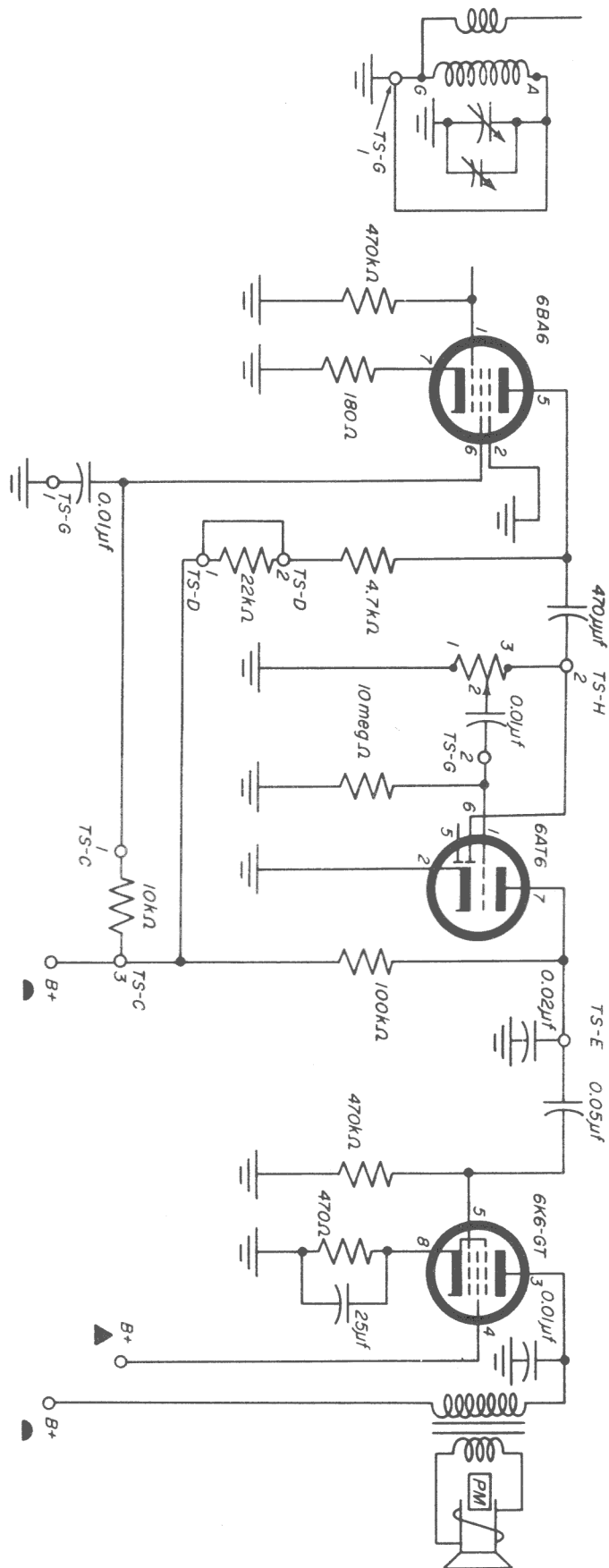
On the other hand, when the plate load is 4.7 k-ohms, and it is shunted by the same capacitance, the net plate load impedance at 500 kc is about 4.5 k-ohms; at 1,500 kc it is reduced to 4 k-ohms, a reduction of only

about 13 percent. When a lower plate load is used, a more constant load is presented to the tube over the broadcast band, and more uniform gain is obtained. This is verified by the experimental results.

The experiment compares a plate load of 4.7 k-ohms and a plate load of 27 k-ohms in such a way that the operating voltages are unchanged. We find that the smaller plate load is more desirable because it gives more uniform gain at only a slight total loss in gain. However, by using the 4.7 k-ohm resistor alone, the operating voltages to the tube are increased, and we obtain higher uniform gain over the entire band than with the previous loads.

Typical experimental results for this experiment are shown in Table G below. Graphs plotted from these results are given in Fig. 28-8.

TABLE G - RELATIVE GAIN OF R-F STAGE			
Load	600 kc	1,000 kc	1,600 kc
27 k-ohm Plate Load	5.8	4.4	3.5
4.7 k-ohm Plate Load, $E_b = 20v$	4	3.2	2.8
4.7 k-ohm Plate Load, $E_b = 200 v$	11.0	9.7	8.4



Condition of Radio Receiver Chassis at End of Experiment Lesson 28